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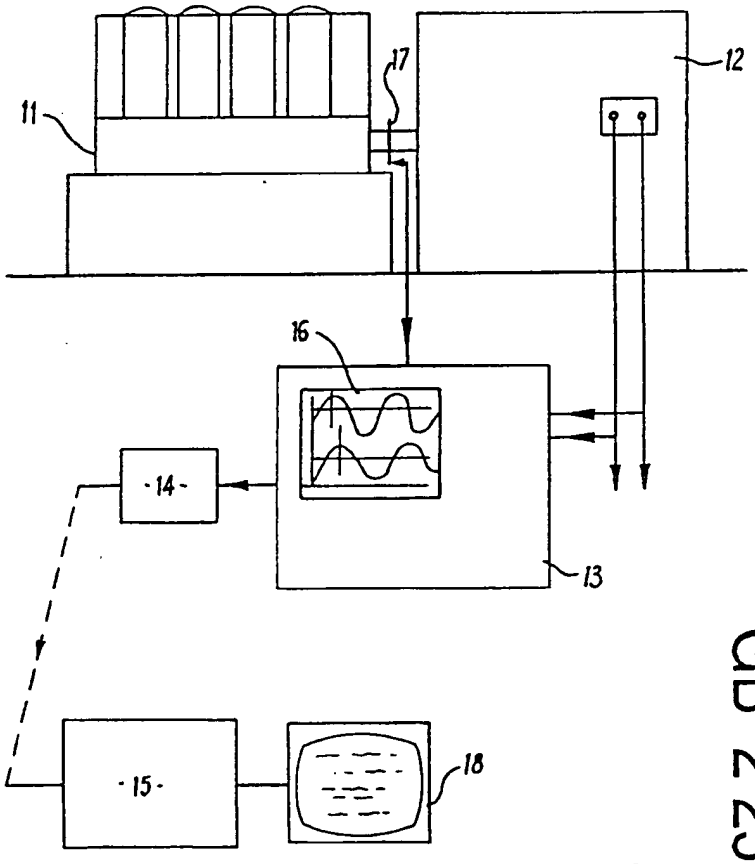
(54) Engine power balance monitor

(57) An engine-generator combination, particularly of a four-cylinder reciprocating engine (11) with an a.c. synchronous generator (12), is provided with a monitoring system to identify engine power imbalance which gives rise to variation in output torque. The monitoring system has an engine shaft encoder (17) which provides information on the position of the shaft relative to a zero position, and the output current and/or phase angle between the voltage and current waveforms of the generator (12) is monitored. The resulting analogue data can be displayed as waveforms on a display (16) or converted to digital data and analysed, via a modem link (14), at a remote station (15).



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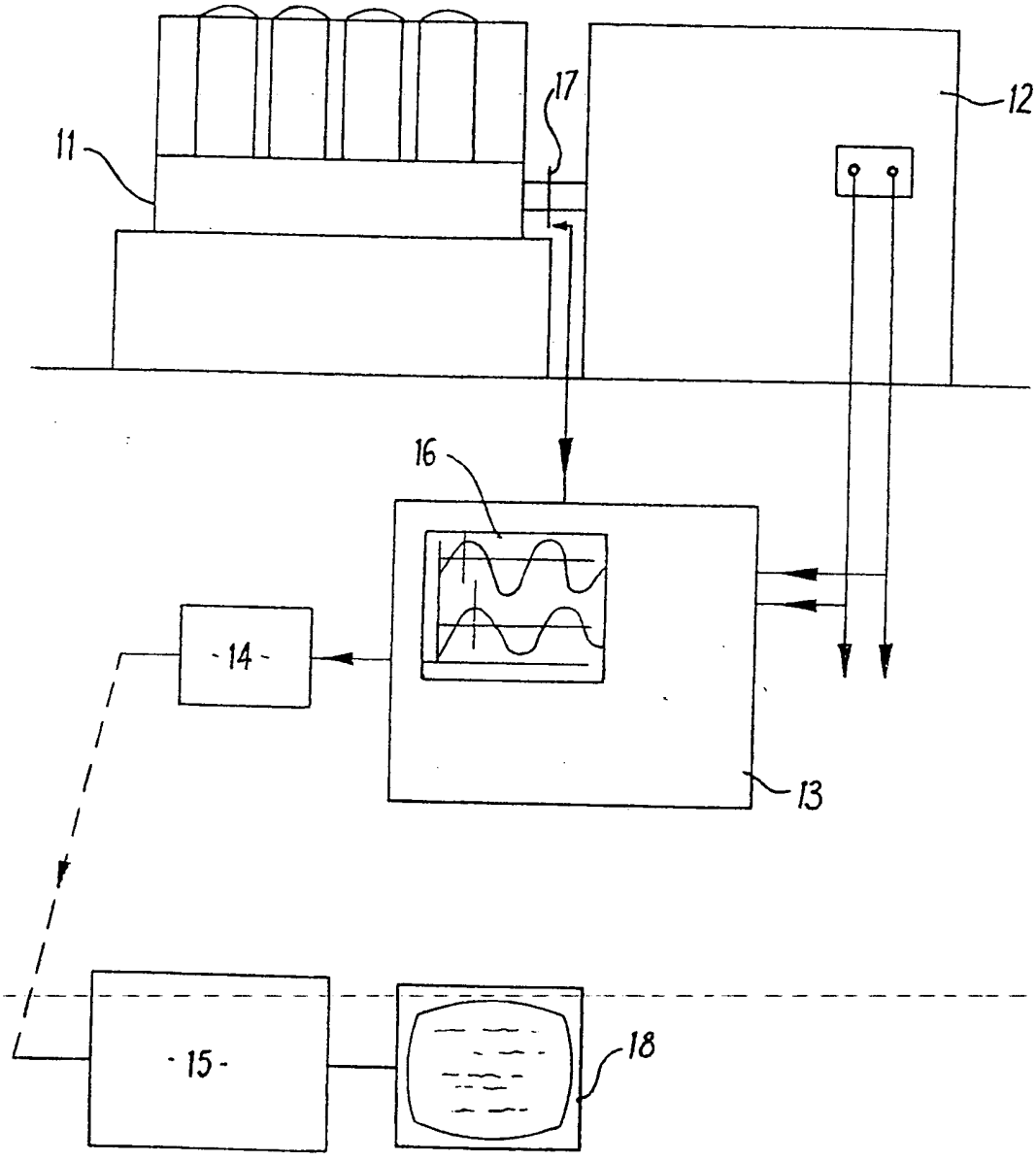
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.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ENGINE POWER BALANCE MONITOR

This invention relates to monitoring engine-generator combinations such as are used to supply electrical power connected in parallel to an electrical grid.

It is in these instances usually important that the equipment is maintained in serviceable condition and that faults are anticipated and corrected in timely fashion so that the equipment operates at peak efficiency and does not fail in service. It is also frequently desirable to have remote monitoring of the equipment.

The engines used in these combinations are usually reciprocating internal combustion engines. Numerous aspects of their operation are already closely monitored in these situations, such for example as oil temperature and pressure, coolant temperature and level, shaft speed and so on.

It is now found that an additional aspect can, with benefit, be monitored, namely the possibility of a power imbalance between the engine cylinders which manifests itself as a cyclic variation in output torque.

The invention comprises a method for monitoring an engine-generator combination, comprising monitoring an output variable of the generator and relating it to the operating cycle of the engine.

It is found, particularly with a synchronous generator operating at fixed speed with a fixed voltage across its output terminals and with fixed excitation, a change in the input shaft torque will result in a change in the load angle of the generator which will be reflected in both the magnitude of the output current and in the phase angle between the voltage and current waveforms.

Thus monitoring output current and/or phase angle will reveal a variation in input torque which could be due to cylinder power imbalance. If the engine shaft position is known, as by a shaft encoder aligned with a known engine shaft position, e.g. T.D.C. on cylinder #1 a fault may be identified with a particular cylinder.

The current and/or phase angle and engine shaft position information may be digitally represented and analysed in a digital processor.

The invention also comprises monitoring apparatus for an engine-generator combination comprising generator output variable detector means and engine cycle sensing means and comparison means for the output variable and engine cycle information adapted to indicate how the variable varies during the engine cycle.

One embodiment of monitoring apparatus and a method according to the invention will now be described with reference to the accompanying drawing, in which the single Figure is a diagrammatic representation.

The Figure illustrates a four cylinder reciprocating engine 11 coupled to a synchronous generator 12. A microprocessor- or computer-based controller 13 is supplied with digitally represented information about engine and generator variables from a range of sensors, not generally shown, for pre-processing and onward transmission via a modem 14 to a remote monitoring station 15.

The usual operating variables monitored in e.g. a combined heat and power system include generator voltage, current and frequency and engine temperature and fluid levels. Thus in such an arrangement there will usually be instrumentation from which the generator variables can be derived for the present monitoring

arrangement, but specifically, the a.c. generator output voltage and current values are detected and represented in an analogue meter 16 (which may as illustrated include a CRT display).

A shaft encoder 17 aligned in known relationship to the position e.g. of the #1 cylinder, e.g. zeroed at cylinder #1 T.D.C., also inputs to the meter 16 to reference the voltage and current curves to the shaft position.

The analogue data can be digitally represented by conversion in the microprocessor 13 or a separate A-D converter for transmission over the modem 14 to the remote station 15 where after analysis (e.g. by a fast fourier transform or otherwise) a diagnosis of any problem occurring in the engine can be displayed on a screen 18 or print-out, e.g. "No. 3 cylinder, 10% power deficiency".

Of course, power fluctuations might be due to other factors and diagnostic programmes might be devised that would not only identify the cylinder involved but a likely cause associated with the cylinder, such for example as a faulty piston ring, a faulty spark plug (if other than a diesel engine), a faulty bearing or whatever, or even a cause not associated with the cylinder.

CLAIMS

1. A method for monitoring an engine-generator combination, comprising monitoring an output variable of the generator and relating it to the operating cycle of the engine.

2. A method according to claim 1 wherein the generator is a synchronous a.c. generator.

3. A method according to claim 2 wherein the generator operates at fixed speed with a fixed voltage across output terminals thereof and with fixed excitation, whereby a change in the input shaft torque results in a change in the load angle of the generator, and the monitored said output variable is the magnitude of the output current and/or the phase angle between the voltage and current waveforms.

4. A method according to any one of claims 1 to 3 wherein the engine shaft position is monitored to provide information on the operating cycle of the engine.

5. A method according to claim 4 wherein the engine shaft position is monitored with a shaft encoder aligned with a known engine shaft position.

6. A method according to claim 3 with claim 4 or 5 wherein the current and/or phase angle and engine shaft position

information are digitally represented and analysed in a digital processor.

7. Monitoring apparatus for an engine-generator combination comprising generator output variable detector means, engine cycle sensing means, and comparison means for the output variable and engine cycle information adapted to indicate how the variable varies during the engine cycle.

8. Monitoring apparatus according to claim 7, for an engine-synchronous a.c. generator combination, wherein the generator output variable detector means monitors the output current and/or the phase angle between the voltage and current waveforms.

9. Monitoring apparatus according to claim 7 or 8 wherein the engine cycle sensing means comprises means for monitoring the engine shaft position.

10. Monitoring apparatus according to claim 9 wherein the means for monitoring the engine shaft position comprises a shaft encoder aligned with a known engine shaft position.

11. Monitoring apparatus according to any one of claims 7 to 10 wherein the comparison means comprises a meter which displays analogue data representing said output variable and

said engine cycle information.

12. Monitoring apparatus according to any one of claims 7 to 11 wherein said comparison means comprises a converter which converts analogue data representing said output variable and said engine cycle information to digital data.

13. Monitoring apparatus according to claim 12 including a remote analysis station and a modem link via which said digital data is arranged to be transmitted to the station.

14. Monitoring apparatus according to claim 7 substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

15. An engine-generator combination provided with monitoring apparatus according to any one of claims 7 to 14.

Patents Act 1977
Ex iiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition K) G1N (NAAG, NAAH, NAAJ, NACN)

(ii) Int CL (Edition 5) G01M 15/00

Search Examiner
M G CLARKE

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
30 APRIL 1992

Documents considered relevant following a search in respect of claims 1-15

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X E	WO 91/05233 A1 (ROBERT BOSCH GmbH) See especially Figure 2 pages 8,9 and Claims 1, 8	1, 7

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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&: Member of the same patent family, corresponding document.

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